DEPARTMENT OF HEALTH & HUMAN SERVICES
Public Health Service

Agency for Toxic Substances
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Mr. D. E. Carlson
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Dear Mr. Carlson:

Thank you for the opportunity to review the Phase II Remedial Investigation (RI) Report for the Old Fire Training Area at the Newport Naval Education and Training Center (NETC) in Newport County, Rhode Island. The Agency for Toxic Substances and Disease Registry (ATSDR) prepared a Public Health Assessment (PHA) for NETC in August, 1993. In the PHA, ATSDR recommended sampling of shellfish in order to characterize potential contaminant levels and identify possible public health issues related to human consumption. Shellfish and sediment sampling was performed and the results of these analyses were included in the Phase II (RI) Report for NETC. Samples were collected from three areas at or near NETC: the McAllister Point Landfill (site 01), the Old Fire Training Area (site 09), and the Melville North Landfill (site 02). Analyses were performed for polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), metals and butyltins in several types of shellfish, including blue mussels (Mytilus edulis), soft-shell clams (Mya arenaria), and hard-shell clams (Mercenaria mercenaria).

ATSDR has reviewed these data as well as information concerning local patterns of bivalve contamination and contaminant toxicity. *We have concluded that consumption of shellfish from NETC does not appear to pose a health hazard for the general public; however, there may be specific sub-populations, including local subsistence fishermen, who should be informed not to exceed ATSDR's recommended maximum consumption rates for the species evaluated.* Mussels at site 01 and soft-shell clams at site 09 have slightly higher levels of contamination than local shellfish and should be monitored biennially, or at least every 5 years, to ensure that contaminant concentrations remain at levels that do pose a health hazard to the general public or specific sub-populations, such as subsistence fishermen.

Details of our evaluation are enclosed. Should you have any questions, please contact me at (404) 639-6039.

Sincerely yours,

Brenda K Edmonds

Brenda K. Edmonds, Ph.D.
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Enclosure

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Health Consultation

NEWPORT NAVAL EDUCATION/TRAINING CENTER

MIDDLETOWN, NEWPORT COUNTY, RHODE ISLAND

CERCLIS NO. RI6170085470

DECEMBER 12, 1996

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

HEALTH CONSULTATION

NEWPORT NAVAL EDUCATION/TRAINING CENTER

MIDDLETOWN, NEWPORT COUNTY, RHODE ISLAND

CERCLIS NO. RI6170085470

Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

STATEMENT OF ISSUES

PURPOSE

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared a Public Health Assessment (PHA) for the Naval Education and Training Center (NETC), Middletown, Rhode Island in August 1993 [1] In the PHA, ATSDR recommended sampling of aquatic biota in order to characterize contaminant concentrations and potential human exposure. Additional sampling was performed and the results of these analyses are included in the Phase II Remedial Investigation (RI) Report for NETC [2]. Shellfish and sediment samples were collected from three areas at or near NETC: the McAllister Point Landfill (site 01), the Old Fire Training Area (site 09), and the Melville North Landfill (site 02). For comparison, shellfish and sediment samples were also collected from three reference areas assumed to represent background contaminant levels. In this Health Consultation, ATSDR evaluated these data using several screening level approaches in order to identify possible human health hazards related to consumption of shellfish from NETC.

CONCLUSIONS

ATSDR evaluated sampling and analysis data for polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), metals and butyltins in several types of shellfish, including blue mussels (Mytilus edulis), soft-shell clams (Mya arenaria), and hard-shell clams (Mercenaria mercenaria). ATSDR also reviewed information concerning local patterns of bivalve contamination and contaminant toxicity. We have concluded that:

1) Consumption of shellfish from sites 01, 02 and 09 does not appear to pose a health hazard for the general public; however, there may be specific sub-populations, including local subsistence fishermen, who should be informed not to exceed recommended maximum consumption rates, and

2) PCB levels in mussels at site 01 and PAH levels in soft-shell clams at site 09 have slightly higher levels of contamination than local shellfish and should be monitored every two years (biennially), if resources permit, to ensure that contaminant concentrations remain at levels which do not pose a public health hazard. If biennial screening is not possible, then ATSDR recommends that sampling be conducted at least once every 5 years [15].

BACKGROUND AND SITE DESCRIPTION

The NETC site is located in three townships (Newport, Middletown and Portsmouth) of Newport County, Rhode Island. The installation is approximately 1,063 acres in size and is situated on the

western shore of Aquidneck Island facing Narragansett Bay. The Navy began activities at the installation in 1869 by establishing an experimental Torpedo Station. During World War I, the installation was used as a fueling facility and torpedo development center. In 1946, following World War II, the Torpedo Station was deactivated. By 1974, Naval forces in the Newport area were reorganized and the installation was renamed the Naval Education and Training Center (NETC) The NETC installation was placed on the Environmental Protection Agency's (EPA's) National Priorities List in November, 1989. The EPA completed Phase I of the Remedial Investigation (RI) for NETC in November 1991. The Phase II RI report was published in 1994 and included analytical data for shellfish and sediment sampled from three areas of NETC, the McAllister Landfill (site 01), the Mellville North Landfill (site 02) and the Old Fire Training Area (site 09), as well as three reference areas (R-1 through R-3) (Fig. 1). These data were reviewed by ATSDR in this Health Consultation.

DISCUSSION

ATSDR reviewed the available sampling and analysis data for PCBs, PAHs, metals and butyltins in mussels, soft-shell (near shore) clams, and hard-shell (off shore) clams. A total of 16 PAHs (PAH_{16}) and a single PCB mixture (Aroclor 1254) were selected for evaluation in this Health Consultation. They are presented in Table 1. The contaminants were selected based on tissue concentration, toxicity and data quality [2, 6].

Several approaches were used to perform the screening level assessment:

1) Mean concentrations of total PAH_{16} and PCB Aroclor 1254 were calculated as micrograms per kilogram (µg/kg) dry weight and compared with levels reported for mussels in the Mussel Watch Project of the National Oceanic and Atmospheric Administration (NOAA), a national surveillance system that monitors spatial distributions and temporal trends of contaminant concentrations in coastal and estuarine regions of the United States [3,4].

2) Mean concentrations of total PAH_{16} and PCB Aroclor 1254 were calculated as milligrams per kilogram (mg/kg) wet weight and used to derive Recommended Maximum Consumption Rates (RMCRs) for ingestion of shellfish from NETC. The RMCRs are intended to represent "safe" (allowable) rates of consumption that would not be expected to cause adverse health effects over specified periods of exposure. In addition, wet weight concentrations were used to estimate human exposure doses and cancer risks in order to determine possible public health hazards for ingestion of shellfish from NETC.

Potentially Exposed Populations

Potentially exposed populations include persons who ingest shellfish from waterways near NETC sites 01, 02 and 09 A local shellfish consumption survey has not been conducted; therefore,

site-specific information about the types and frequency of shellfish consumed is not available. The area supports commercial fishing and shellfish industries which may constitute pathways for human exposure It is not known whether subsistence fishing occurs near NETC. In the absence of site-specific rates of consumption, consumption rates derived from regional surveys were used in this screening level assessment. A range of 6 to 30 grams per day (g/day), which corresponds to approximately 1 to 4 (8-ounce) meals per month, was used as the shellfish consumption rate for NETC [8-10]. Consumption was assumed to occur over a period of 6.5 years, which is the median residency time for householders in the three townships (Portsmouth, Middletown, and Newport) where NETC is located, based on population and housing data from the 1990 Census [5].

Screening Level Approach 1: Comparison with Mussel Watch Data

The NOAA Mussel Watch Project is a surveillance program that monitors geographic distributions and temporal trends in contaminant concentrations in mollusks (mussels or oysters) at approximately 150 coastal locations throughout the United States. The samples are located in areas which have no known sources of environmental contamination and are, therefore, considered representative of background conditions. Total PAH_{16} concentrations in shellfish (mussels, clams) at NETC were compared with mean annual concentrations reported for Mussel Watch samples (mussels) collected at 7-9 locations near NETC during the period from 1986 to 1993. These data are presented in Table 2.

Mussels

Mean tissue PAH_{16} levels of mussels from sites 01, 02 and 09 and the reference areas at NETC ranged from 21 to 64 µg/kg and were similar to levels for the Mussel Watch Project samples (mussels), which ranged from 15 to 63 µg/kg

Clams

Mean PAH_{16} concentrations of clams from sites 01 and 02 of NETC ranged from 15 to 45 µg/kg and were similar to levels for Mussel Watch samples (mussels). The mean PAH_{16} concentration of soft-shell clams at site 09 was 250 µg/kg, which was an order of magnitude higher than reported for the Mussel Watch Project. *ATSDR recommends that if soft-shell clams from site 09 are being harvested for human consumption, then contaminant concentrations of PAHs be monitored biennially, or at least every 5 years, to ensure that contaminants remain at levels that do not pose a public health threat.*

Screening Level Approach 2: Calculation of Recommended Maximum Consumption Rates (RMCRs)

Exposure to PAHs and PCBs has been shown to produce both cancer and non-cancer effects in animals [6,7] ATSDR's screening level RMCRs were calculated using cancer as the endpoint of toxicity. Consumption rates based on cancer are generally more restrictive than rates based on non-cancer effects, and are therefore, generally more protective of public health. The RMCRs calculated for NETC are presented in Table 3 for PAHs and in Table 4 for PCB Aroclor 1254. Analytical data for PCBs and PAHs were not combined, but rather were evaluated separately, and RMCRs were calculated on a site-specific, chemical-specific basis. Table 5 provides a summary of the most conservative (i.e., most protective) RMCRs calculated for each type of shellfish and NETC site.

One inherent assumption in calculating screening RMCRs is that all shellfish consumed by potentially exposed persons are obtained from site 01, 02 or 09, and are contaminated by PCBs and PAHs. However, it is more likely that individuals will obtain only a fraction of the total shellfish consumed from NETC [8]. Exposures to site-related contaminants may therefore be less than expected based on the RMCR because other sources of shellfish, which are presumably non-contaminated, will also be consumed Additional assumptions made in calculating the RMCRs are provided in Appendix A.

ATSDR's calculated RMCRs for NETC and compared them to regional shellfish consumption rates in order to determine potential public health hazards. That is, if screening level RMCRs for NETC were lower than regional consumption rates, then further data evaluation and assessment of public health hazard for NETC was considered. Shellfish consumption for the region is approximately 6 to 30 grams per day, or approximately 1 to 4 (8-ounce) meals per month [8-10]. The upper end of this range of consumption rates, 4 meals per month, is considered representative of subsistence fishermen [11] and is generally higher than expected for the general public It is not known whether subsistence fishing is occurring at NETC. ATSDR used this upper end consumption rate in order to be protective of all potentially exposed populations at NETC, including subsistence fishermen.

Calculation of RMCRs based on PAHs

Most PAHs do not appear alone in the environment, but rather as complex mixtures of many individual PAHs which may be carcinogenic or non-carcinogenic. It has been proposed that the carcinogenic activity of PAH mixtures depends primarily on the carcinogenic rather than the non-carcinogenic PAHs, although non-carcinogenic PAHs may increase the toxic potency of carcinogenic PAHs [2] Benzo(a)pyrene is considered to be one of the most potent carcinogenic PAHs [2, 6]. ATSDR's screening RMCRs were calculated using Toxic Equivalency Factors (TEFs) to approximate the carcinogenic potency of PAH mixtures in tissue samples [2]. Each of

the 16 PAHs has been assigned a TEF value based on its carcinogenic potency relative to benzo(a)pyrene These are presented in Table 1. Both carcinogenic and non-carcinogenic PAHs have been assigned TEF values because mixtures typically contain both types of PAHs and both are thought to contribute to carcinogenic potency. The seven carcinogenic PAHs have been assigned TEF values ranging from 5 to 0 01; the nine non-carcinogenic PAHs have been assigned TEF values ranging from 0.01 to 0.001 [2]. The **total TEF** for a tissue sample represents the overall cancer potency for the PAH mixture and is calculated by summing the TEF value for each PAH in the mixture.

The screening level RMCRs calculated for PAHs are provided in Table 3. Two exposure durations, 6.5 and 30 years, were assumed. The value 6.5 years was used to represent an average exposure time because it is the median residency for householders in townships near NETC [5]. The value of 30 years was used to represent average lifetime exposure [13].

PAHs are metabolized by aquatic organisms via the mixed function oxygenase enzyme, arylhydrocarbon hydroxylase (AHH). Invertebrates such as shellfish generally have low AHH activity, and therefore, tend to accumulate PAHs and related metabolites, particularly in lipid-rich tissues such as fat. A primary source of PAHs for accumulation by shellfish is contaminated sediment. It is difficult to determine the extent to which contaminated sediments constitute a continual source of PAH contamination for shellfish at NETC because there is a general lack of data regarding the partitioning of PAHs between soil/sediments and the body fluids of aquatic organisms Because it is difficult to predict whether contaminant levels in shellfish will increase or decrease in the future, *ATSDR recommends sampling shellfish and sediment at least biennially, or at least every 5 years, in particular at site 09 which had elevated contaminant levels, in order to ensure that contaminant levels do not increase to levels that may pose a future threat to public health.*

Calculation of RMCRs based on PCBs

Aroclor is the trade name of commercial mixtures of PCBs. The adverse health effects from exposure to Aroclors depends primarily on the toxicity of the individual PCB components [7]. The EPA is currently updating the cancer dose-response assessment for PCBs based on a re-evaluation of existing lifetime cancer studies in animals and on a recent study indicating that all Aroclor mixtures can pose a risk of cancer Aroclor-specific cancer potency estimates have been developed [12] The PCB mixture detected in mussels and clams at sites 01, 02 and 09 was reported to be Aroclor 1254. The screening RMCRs calculated for PCBs are based on the revised cancer potency estimate for Aroclor 1254.

The screening RMCRs calculated for PCBs are provided in Table 4. Two exposure durations, 6.5 and 30 years, were assumed. A value of 6.5 years was used to represent an average exposure time, based on median residency near NETC. A value of 30 years was used to represent average lifetime exposure [13].

Screening Level Approach 3: Estimation of Exposure Doses and Cancer Risk

ATSDR estimated exposure doses and cancer risks for PAHs and PCBs in shellfish from the three sites at NETC These values are presented in Tables 6 and 7. Regional shellfish consumption rates (1 to 4 meals per month) were used to calculate cancer risks [8-10]. Additional assumptions are provided in Tables 6 and 7. Based on these calculations and available toxicological data for the chemicals evaluated, *ATSDR concluded that ingestion of shellfish from sites 01, 02 and 09 does not pose a public health hazard. However, there may be a slight risk of developing cancer (e.g., 1 to 5 in 10,000) from lifetime consumption of large quantities of shellfish (i.e., equal to or more than 30 grams per day or 4 meals per month) from these areas as well as from the reference areas evaluated.*

Mixed shellfish meals

ATSDR recognizes that most people consume a variety rather than a single type of shellfish and they are likely to obtain their shellfish from many different sources, both contaminated and non-contaminated. In addition, a single type of shellfish may be contaminated by more than one type of chemical (e.g., PAHs, PCBs). Therefore, it is difficult to determine a reasonable maximal exposure for the various possible combinations of seafood meals. The screening level RMCRs, exposure doses and cancer risks were calculated assuming that individuals would consume a single type of shellfish (e.g., mussel, soft-shell clam, or hard-shell clam) contaminated by a single chemical (e.g., PAHs or PCBs) from a single site (e.g., 01, 02, or 09). *In order to be protective of public health, ATSDR recommends that consumption of shellfish for a site (e.g., 01, 02 or 09) be limited to the most conservative (lowest) RMCR calculated for that site and type of shellfish.* These values are presented in Table 5. For instance, consumption of mussels at site 01 should be based on PCBs, rather than PAHs, and be limited to 4 meals per month for an average exposure time (6 5 years) and 1 meal per month for lifetime exposure (30 years) These rates are considered more protective of public health than those calculated for PAHs (e.g., 46 and 10 meals per month, respectively).

Conclusions and Recommendations

1). Based on calculation of cancer risks (Tables 6 and 7) and comparison of ATSDR's screening level RMCRs (Table 5) with regional rates of shellfish consumption (e.g., 1 to 4 meals per month), *ATSDR concludes that consumption of shellfish from waterways at NETC does not pose a public health hazard for the general public.*

The evidence for carcinogenicity following ingestion of PAHs and PCBs in humans is inconclusive or lacking; however, both classes of contaminants have been shown to produce cancer in animals following oral exposure at relatively high doses [6,7]. For

PAHs, sufficient increases in gastric tumors have been reported in animals following oral administration of 2.6 mg/kg/day benzo(a)pyrene for up to one year. By contrast, the highest estimated lifetime exposure dose for persons ingesting shellfish from NETC was 7×10^{-6} mg/kg/day, more than 300,000 times lower than the experimental dose shown to produce cancer in laboratory animals. For *PCBs*, significant increases in liver cancer have been reported at doses of 1.25 to 5 mg/kg/day in animal studies. By contrast, the highest estimated lifetime exposure dose for PCB for persons ingesting shellfish from NETC was 2×10^{-5} mg/kg/day, more than 100,000 times lower than the experimental doses.

Despite the apparent differences between the experimental doses of PAHs and PCBs shown to produce cancer in laboratory studies and the estimated exposures for persons ingesting shellfish at NETC, *ATSDR recommends that consumption of shellfish from NETC be limited to the most conservative (lowest) RMCRs calculated for each type of shellfish at each site (01, 02, and 09)*. These values are provided in Table 5. For instance, consumption of soft-shell clams from site 09 should be limited to 3 (8-ounce) meals per month based on average exposure time and 1 meal per month based on lifetime exposure. The RMCRs are protective of human health for both cancer and non-cancer effects of PAHs and PCBs. They are also protective of specific sub-populations, including subsistence fishermen who may frequently ingest shellfish from NETC and developing fetuses which may be at increased risk of adverse effects from exposure to these types of contaminants.

2) Contaminant levels for mussels at site 01 and soft-shell clams at site 09 were higher than for background areas and the Mussel Watch Project. ATSDR recommends monitoring contaminant concentrations in shellfish and sediment biennially, or at least every 5 years, if shellfish from these areas are being harvested for recreational or commercial/industrial purposes.

3). If additional information becomes available indicating that contaminant levels (for shellfish and/or sediment) or local consumption rates have increased, a re-evaluation of public health hazards for NETC may be necessary.

APPENDIX A

Assumptions for Calculating RMCRs and Cancer Risks

1. For both mussels and clams, a single seafood meal was assumed to be 0.227 g (approximately 8 ounces) [13].

2. An adult body weight of 70 kg was assumed [13].

3. Average concentrations were used to represent realistic exposures to contaminants.

4. The following formulas were used to calculate Recommended Maximum Consumption Rates (RMCRs) [13 - 15].

$$\text{RMCR (meals/month)} = \frac{\text{BodyWeight (kg)} * \text{Dose (mg/kg/d)} * \text{AveragingTime (d)}}{\text{Aver.Conc (mg/kg)} * \text{IngestionRate (kg/d)} * \text{ExposureDuration (yr.)} * 12 \text{ mo /yr.}}$$

Where:

Dose = Dose of chemical corresponding to a 1 in 10^{-5} cancer risk:

$$\text{Dose (mg/kg/d)} = \frac{10^{-5}}{\text{CancerPotencyFactor (mg/kg/d)}^{-1}}$$

5. Screening RMCRs were calculated assuming both average (e.g., 6.5 years) and lifetime (e.g , 30 years) exposure durations The 6 5-year duration represented median residency for householders in townships near NETC based on 1990 data from the U.S. Census Bureau [5]. The 30-year duration represented average lifetime exposure [13]

6 The following formulas were used to calculate exposure dose and cancer risk [13, 14]:

$$\text{ExposureDose (mg/kg/d)} = \frac{\text{Aver Conc (mg/kg)} * \text{IngestionRate (kg/d)} * \text{ExposureDuration (yr} * 365 \text{ d/yr)}}{\text{BodyWeight (kg)} * \text{AveragingTime (d)}}$$

$$\text{CancerRisk} = \text{ExposureDose (mg/kg/d)} * \text{CancerPotencyFactor (mg/kg/d)}^{-1}$$

PAHs

7. A total of 16 PAHs were evaluated using a Toxic Equivalency Factor (TEF) approach which relates the cancer potency of individual compounds to benzo(a)pyrene in order to derive an total TEF value for the mixture of PAHs in each shellfish sample [2]. A cancer potency factor of 7.3 $(mg/kg/day)^{-1}$ for benzo(a)pyrene was assumed [6].

PCBs

8. A cancer potency estimate of 2 $(mg/kg/day)^{-1}$ for Aroclor 1254 was assumed for food chain exposure based on EPA's re-evaluation of cancer studies in animals [12].

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Table 1
Contaminants Evaluated

PAHs	Toxic Equivalency Factor (TEF)[a]
Carcinogenic:	
Benzo(a)pyrene	1
Dibenzo(a,h)anthracene	5
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Indeno(g,h,i)perylene	0.1
Chrysene	0.01
Non-carcinogenic:	
Anthracene	0.01
Benzo(g,h,i)perylene	0.01
Acenaphthene	0.001
Acenaphthehylene	0.001
Fluoranthene	0.001
Fluorene	0.001
Naphthalene	0 001
Phenanthrene	0.001
Pyrene	0.001

PCBs

Aroclor 1254

[a] reference: Nisbet, 1992

Table 2. Newport Naval Education/Training Center (NETC)
Comparison of Shellfish PAH_{16} Concentrations with NOAA Mussel Watch Data
(all values presented in micrograms per kilogram, dry weight, for 16 Total PAHs, PAH_{16})

	MUSSELS		SOFT-SHELL CLAMS		HARD-SHELL CLAMS	
	Mean Total PAH_{16}	Mean Total TEF	Mean Total PAH_{16}	Mean Total TEF	Mean Total PAH_{16}	Mean Total TEF
McAllister Point Landfill (site 01)	33	2 1	45	4 9	40	3 3
Melville North Landfill (site 02)	28	1 9	26	2.0	15	0.7
Old Fire Training Area (site 09)	64	5 7	250	36	21	1.9
Reference Areas	21	1.9	33	3.5	29	3 0
Mussel Watch Project						
1986	63	8 6				
1987	49	0.9				
1988	35	0.1				
1989	15	0 1				
1990	19	0.3				
1991	18	0.3				
1992	25	0.6				
1993	35	1.7				

TEF = Toxic Equivalency Factor (Nisbet, 1992)
PAH_{16} = Total mean concentration for 16 PAHs (Table 1)

Table 3 Recommended Maximum Consumption Rates (RMCRs) for Shellfish at Newport Naval Education/Training Center

(Based on Toxic Equivalency Factor, TEF, Analysis for Total Polycyclic Aromatic Hydrocarbons, PAH_{16})

McAllister Point Landfill (Site 01)					
				Recommended Max	Recommended Max
		Mean Concentration	Mean	Consumption	Consumption
		PAH_{16}	Total TEF	6 5-yr duration	30-yr duration
		(mg/kg, wet wt)	*(mg/kg, wet wt)*	*(meals/month)*	*(meals/month)*
Mussels		0.039	0 003	46	10
Clams	Soft-shell	0 043	0 005	28	6
	Hard-shell	0 037	0.003	46	10
Melville North Landfill (Site 02)					
Mussels		0.038	0.002	69	15
Clams	Soft-shell	0 029	0 002	69	15
	Hard-shell	0 019	0.001	138	30
Old Fire Training Area (Site 09)					
Mussels		0 074	0 006	23	5
Clams	Soft-shell	0.276	0 040	3	1
	Hard-shell	0 029	0.002	69	15
Reference Areas					
Mussels		0 023	0 002	69	15
Clams	Soft-shell	0 030	0 003	46	10
	Hard-shell	0 025	0 003	46	10

Exposure duration 6.5 yr is the median residency in NETC area; 30 yr represents average lifetime exposure (U S Census, 1992, EPA, 1995)

PAH_{16} = Total of 16 PAHs (Table 1)

Toxic equivalency factor (TEF) analysis based on relative potency to benzo(a)ptrene (Nisbet, 1992)

Mean concentrations of total PAH_{16} based on mg/kg, wet weight

Meal size assumed to be 0 227 kg (8 oz) per meal (EPA, 1995)

Body weight assumed to be 70 kg (EPA, 1995)

Soft-shell clams = near shore clams, hard shell clams = offshore clams

Table 4. Recommended Maximum Consumption Rates (RMCRs) for Shellfish at				
Newport Naval Education/Training Center				
(Based on Polychlorinated Biphenyl, Arochlor 1254)				
McAllister Point Landfill (Site 01)				
			Recommended Max.	Recommended Max
		Mean Concentration	Consumption	Consumption
		Arochlor 1254	6.5-yr duration	30-yr duration
		(mg/kg, wet wt)	*(meals/month)*	*(meals/month)*
Mussels		0 115	4	1
Clams	Soft-shell	0 008	63	14
	Hard-shell	0.012	42	9
Melville North Landfill (Site 02)				
Mussels		0.051	10	2
Clams	Soft-shell	0.008	63	14
	Hard-shell	0.006	84	18
Old Fire Training Area (Site 09)				
Mussels		0.037	14	3
Clams	Soft-shell	0 004	126	27
	Hard-shell	0 006	84	18
Reference Areas				
Mussels		0 041	12	3
Clams	Soft-shell	0 003	168	36
	Hard-shell	0 009	56	12
Exposure duration 6.5 yr. is the median residency in NETC area,				
30 yr. represents average lifetime exposure (EPA, 1995)				
Cancer potency factor assumes upper-bound estimate for Arochlor 1254 based on				
re-evaluation of lifetime cancer studies in animals (EPA, 1996)				
Mean concentrations of Arochlor 1254 based on mg/kg, wet weight				
Meal size assumed to be 0.227 kg (8 oz.) per meal (EPA, 1995)				
Body weight assumed to be 70 kg (EPA, 1995)				
Soft-shell clams = near shore clams, Hard-shell clams = offshore clams				

Table 5 Summary of Lowest Recommended Maximum Consumption Rates (RMCRs) for Ingestion of Shellfish at Newport Naval Education/Training Center (Based on average concentrations of total PAHs, PAH_{16}, or PCBs)					
		Lowest RMCR (meals/month) *(average exposure)*	Chemical	Lowest RMCR (meals/month) *(lifetime exposure)*	Chemical
McAllister Point Landfill (Site 01)					
Mussels		4	PCBs	1	PCBs
Soft-shell Clams		28	PAHs	6	PAHs
Hard-shell Clams		42	PCBs	9	PCBs
Melville North Landfill (Site 02)					
Mussels		10	PCBs	2	PCBs
Soft-shell Clams		63	PCBs	14	PCBs
Hard-shell Clams		84	PCBs	18	PCBs
Old Fire Training Area (Site 09)					
Mussels		14	PCBs	3	PCBs
Soft-shell Clams		3	PAHs	1	PAHs
Hard-shell Clams		69	PAHs	15	PAHs
Reference Areas					
Mussels		12	PCBs	3	PCBs
Soft-shell Clams		46	PAHs	10	PAHs
Hard-shell Clams		46	PAHs	10	PAHs
Exposure Duration = 6 5 years is the median residency near NETC; 30 yr represents the average lifetime (U S Census, 1992; EPA, 1995)					
RMCR = Recommended Maximum Consumption Rate					
Soft-shell clams = near shore clams; hard-shell clams = offshore clams					
PAHs = sum of 16 PAHs (PAH_{16})					
PCBs = Aroclor 1254					

Table 6. Estimated Exposure Doses and Cancer Risks for Ingestion of Shellfish at Newport Naval Education/Training Center

(Based on Toxic Equivalency Factor, TEF, for 16 PAHs, PAH_{16})

McAllister Point Landfill (Site 01)										
			Exposure	Exposure			Exposure	Exposure		
		Mean Chemical	**Dose**	**Dose**	**CA Risk**	**CA Risk**	**Dose**	**Dose**	**CA Risk**	**CA Risk**
		Concentration	IR = 6 g/d	IR = 30 g/d	IR = 6 g/d	IR = 30 g/d	IR = 6 g/d	IR = 30 g/d	IR = 6 g/d	IR = 30 g/d
		Total TEF	6 5 yr.	6 5 yr	6 5 yr.	6 5 yr.	30 yr.	30 yr.	30 yr.	30 yr.
		(mg/kg, wet wt)	*(mg/kg-day)*	*(mg/kg-day)*			*(mg/kg-day)*	*(mg/kg-day)*		
Mussels		0 003	2 39E-08	1.19E-07	1.74E-07	8.72E-07	1.10E-07	5.51E-07	8.04E-07	4.02E-06
Clams	Soft-shell	0 005	3 98E-08	1 99E-07	2 91E-07	1.45E-06	1.84E-07	9.18E-07	1.34E-06	6.70E-06
	Hard-shell	0 003	2 39E-08	1.19E-07	1.74E-07	8 72E-07	1.10E-07	5.51E-07	8 04E-07	4 02E-06
Melville North Landfill (Site 02)										
Mussels		0 002	1 59E-08	7 96E-08	1.16E-07	5.81E-07	7.35E-08	3 67E-07	5 36E-07	2 68E-06
Clams	Soft-shell	0 002	1.59E-08	7 96E-08	1.16E-07	5 81E-07	7.35E-08	3.67E-07	5.36E-07	2 68E-06
	Hard-shell	0 001	7.96E-09	3 98E-08	5 81E-08	2.91E-07	3.67E-08	1.84E-07	2 68E-07	1 34E-06
Old Fire Training Area (Site 09)										
Mussels		0 006	4 78E-08	2.39E-07	3.49E-07	1.74E-06	2.20E-07	1.10E-06	1.61E-06	8 04E-06
Clams	Soft-shell	0 040	3 18E-07	1.59E-06	2 32E-06	1.16E-05	1.47E-06	7.35E-06	1.07E-05	5 36E-05
	Hard-shell	0 002	1.59E-08	7 96E-08	1.16E-07	5.81E-07	7.35E-08	3.67E-07	5 36E-07	2.68E-06
Reference Areas										
Mussels		0 002	1.59E-08	7 96E-08	1.16E-07	5.81E-07	7.35E-08	3.67E-07	5 36E-07	2 68E-06
Clams	Soft-shell	0.003	2.39E-08	1.19E-07	1.74E-07	8.72E-07	1.10E-07	5.51E-07	8.04E-07	4 02E-06
	Hard-shell	0 003	2 39E-08	1.19E-07	1 74E-07	8.72E-07	1.10E-07	5.51E-07	8 04E-07	4 02E-06
Assumptions										

Exposure duration 6 5 yr. is the median residency near NETC, 30 yr is the average lifetime exposure (U.S. Census, 1992; EPA, 1995)

Toxic Equivalency Factor (TEF) analysis based on relative potency to benzo(a)pyrene (Nisbet, 1992)

Cancer potency factor for benz(a)pyrene is 7.3 mg/kg-day (EPA, 1993)

Mean concentrations of 16 total PAHs (PAH_{16}) based on mg/kg, wet weight

Ingestion Rate assumed to be 6 to 30 g/dy (Cunningham, 1990, Evans, 1992, Rupp, 1980)

Body weight assumed to be 70 kg (EPA, 1995)

Soft-shell clams = near shore clams; hard-shell clams = offshore clams

Exposure Dose = Concentration (mg/kg) * IngestionRate(kg/d) * ExposureDuration (yr*365 d/yr)

BodyWeight(kg) * AveragingTime (d)

Cancer (CA) Risk = Exposure Dose * Cancer potency factor

Table 7 Estimated Exposure Doses and Cancer Risks for Ingestion of Shellfish at Newport Naval Education/Training Center

(Based on Polychlorinated Biphenyl Mixture Aroclor 1254)

McAllister Point Landfill (Site 01)										
		Mean Chemical	Exposure Dose	Exposure Dose	CA Risk	CA Risk	Exposure Dose	Exposure Dose	CA Risk	CA Risk
		Concentration	IR = 6 g/d	IR = 30 g/d	IR = 6 g/d	IR = 30 g/d	IR = 6 g/d	IR = 30 g/d	IR = 6 g/d	IR = 30 g/d
		Aroclor 1254	6 5 yr	6 5 yr	6 5 yr	6 5 yr	30 yr	30 yr	30 yr	30 yr
		(mg/kg, wet wt)	*(mg/kg-day)*	*(mg/kg-day)*			*(mg/kg-day)*	*(mg/kg-day)*		
Mussels		0 115	9 15E-07	4 58E-06	1 83E-06	9 15E-06	4 22E-06	2 11E-05	8 45E-06	4 22E-05
Clams	Soft-shell	0 008	6 37E-08	3 18E-07	1 27E-07	6 37E-07	2 94E-07	1 47E-06	5 88E-07	2 94E-06
	Hard-shell	0 012	9 55E-08	4 78E-07	1 91E-07	9 55E-07	4 41E-07	2 20E-06	8 82E-07	4 41E-06
Melville North Landfill (Site 02)										
Mussels		0 051	4 06E-07	2 03E-06	8 12E-07	4 06E-06	1 87E-06	9 37E-06	3 75E-06	1 87E-05
Clams	Soft-shell	0 008	6 37E-08	3 18E-07	1 27E-07	6 37E-07	2 94E-07	1 47E-06	5 88E-07	2 94E-06
	Hard-shell	0 006	4 78E-08	2 39E-07	9 55E-08	4 78E-07	2 20E-07	1 10E-06	4 41E-07	2 20E-06
Old Fire Training Area (Site 09)										
Mussels		0 037	2 94E-07	1 47E-06	5 89E-07	2 94E-06	1 36E-06	6 80E-06	2 72E-06	1 36E-05
Clams	Soft-shell	0 004	3 18E-08	1 59E-07	6 37E-08	3 18E-07	1 47E-07	7 35E-07	2 94E-07	1 47E-06
	Hard-shell	0 006	4 78E-08	2 39E-07	9 55E-08	4 78E-07	2.20E-07	1 10E-06	4 41E-07	2 20E-06
Reference Areas										
Mussels		0 041	3 26E-07	1 63E-06	6 53E-07	3 26E-06	1 51E-06	7 53E-06	3 01E-06	1 51E-05
Clams	Soft-shell	0 003	2 39E-08	1 19E-07	4 78E-08	2 39E-07	1 10E-07	5 51E-07	2 20E-07	1 10E-06
	Hard-shell	0 009	7 16E-08	3 58E-07	1 43E-07	7 16E-07	3 31E-07	1 65E-06	6 61E-07	3 31E-06

Assumptions

Exposure duration 6 5 yr is the median residency near NETC,

Aroclor 1254, 30 yr is the average lifetime (U S Census 1992, EPA, 1995 and 1996)

Cancer potency factor assumes upper-bound estimate for Aroclor 1254 based on re-evaluation of lifetime cancer studies in animals (EPA, 1996)

Mean concentrations of Aroclor 1254 based on mg/kg, wet weight

Ingestion Rate assumed to be 6 to 30 g/d (Cunningham, 1990, Evans, 1992, Rupp, 1980)

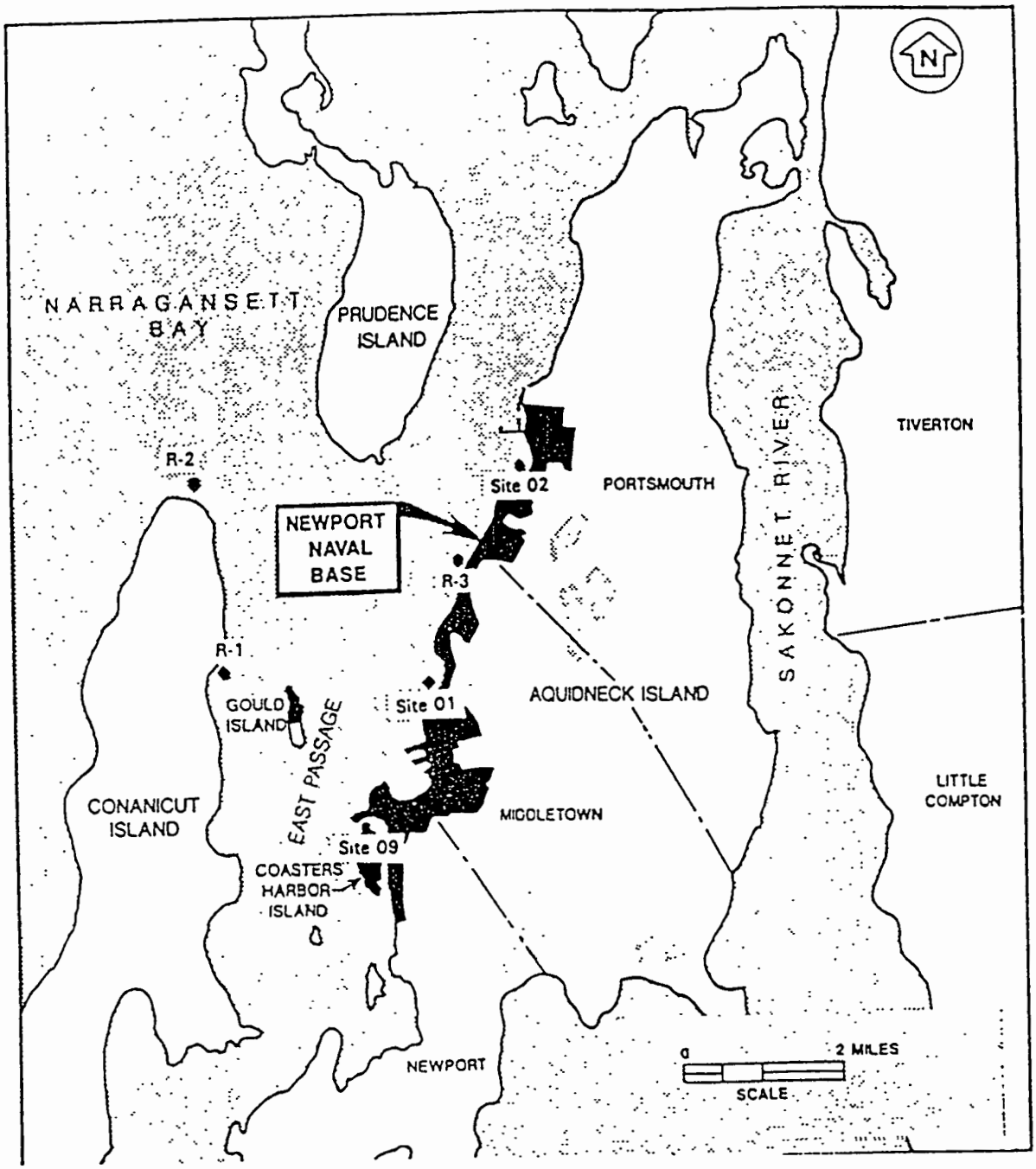
Body weight assumed to be 70 kg (EPA 1995)

Soft-shell clam = near shore clam, hard-shell clam = offshore clam

$$\text{Exposure Dose} = \frac{\text{Concentration(mg/kg)} * \text{IngestionRate(kg/d)} * \text{ExposureDuration(yrs*365 d/yr)}}{\text{BodyWeight(kg)} * \text{AveragingTime(d)}}$$

Cancer (CA) Risk = Exposure Dose * Cancer potency factor

Figure 1. Newport Naval Education/Training Center (NETC)
Sampling Locations



Site 01 = Allister Point Landfill
Site 02 = Melville North Landfill
Site 03 = Old Fire Training Area
R-1, R-2, and R-3 = Reference Areas